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**COLORADO DEPARTMENT OF PUBLIC HEALTH  
AND ENVIRONMENT**

**HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION**

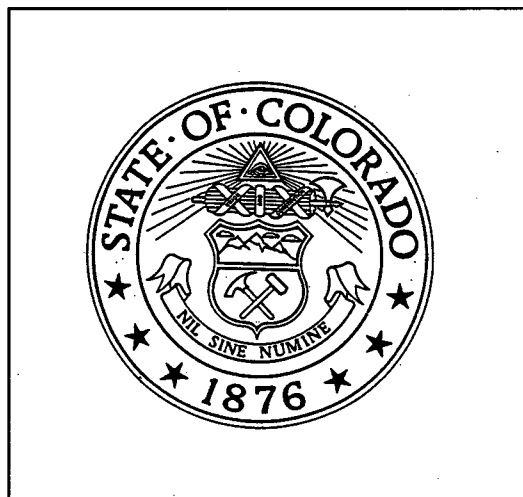
**SITE INSPECTION**

**DRAFT**

**ANALYTICAL RESULTS REPORT**

**CEMENT CREEK WATERSHED (CERCLIS ID # CO0001411347)**

**SAN JUAN COUNTY, COLORADO**



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**SITE INSPECTION  
COMPREHENSIVE ANALYTICAL RESULTS REPORT  
CEMENT CREEK WATERSHED (CERCLIS ID # CO 0001411347)  
SAN JUAN COUNTY, COLORADO**

**1.0 INTRODUCTION**

Under a Cooperative Agreement with the United States Environmental Protection Agency (EPA), the Hazardous Materials and Waste Management Division of the Colorado Department of Public Health and Environment (CDPHE) conducted a Site Inspection (SI) of Upper Cement Creek and Prospect Gulch, known collectively as the Cement Creek Watershed, located near Silverton, San Juan County, Colorado. The study was designed to evaluate the impact of mining in the Silverton Mining District. The work was performed under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or "Superfund"), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), for the EPA Region VIII Superfund Remedial Screening Program. The SI was designed to bridge with sampling efforts of the Colorado Division of Minerals and Geology's (DMG) Non Point Source *Animas River Targeting Continuation Project*, as possible under the Site Assessment Program.

This Comprehensive Analytical Results Report (ARR) presents the results of the sampling program which was conducted from August 6 through October 2, 1996. For background information the reader is referred to the *Animas Discovery Report* (CDPHE, 1995), the Cement Creek Sampling and Analysis Plan (SAP) (CDPHE, 1996a), and the Cement Creek Sampling Activities Report (SAR) (CDPHE, 1996b). The SAR is included as Appendix A.

The sampling conducted by CDPHE complimented the DMG sampling efforts: where DMG collected surface water samples, CDPHE collected collocated sediment samples (of which 10% were analyzed for cyanide and organic compounds); CDPHE analyzed 10% of DMG's surface water samples for cyanide and organic compounds. Where DMG collected aqueous samples, CDPHE collected solid source samples; additionally, CDPHE collected solid source samples where aqueous source samples were not collected by DMG. CDPHE also collected residential drinking water from both groundwater wells and surface water sources at 5 locations.

Site reconnaissance and sampling of mine waste rock source characterization samples were conducted between August 6 and 8, 1996. Ground water sampling activities were carried out on September 16 and 17, 1996. Aqueous and sediment sampling activities occurred on September 30, October 1 and 2, 1996. The sampling was performed in accordance with the Cement Creek Watershed Sample and Analysis Plan (CDPHE, 1996), approved by EPA on July 26, 1996, except as noted in Section 3.0 of the Cement Creek Sample Activities Report.

The CDPHE sampling activities in Cement Creek included the collection of 79 samples. A total of 5 ground water, 6 surface water, 53 sediments, and 15 solid source characterization samples were collected. The 5 ground water samples were analyzed for total and dissolved metals. Six aqueous samples (10 % of DMG surface water) were analyzed for Pesticides/Polychlorinated Biphenyls (PCBs), Base/Neutral/Acid Extractable Organics (BNAs), and Volatile Organics (VOA), Cyanide and Total Organic Carbon (TOC). Six sediment samples collocated with the aqueous samples (10% of CDPHE sediment samples) were also be analyzed for PCBs, BNAs, VOA, Cyanide and total metals. The remaining 47 sediment samples, collocated with DMG's aqueous samples, were analyzed for total metals. Fifteen (15) mine dump source characterization samples were also analyzed for total metals analyses. A duplicate surface water sample, one field blank, one trip blank, and two equipment rinsate blanks (one for groundwater, one for sediments) were collected for quality control samples.

Appendix A, SAR Tables I and II, list the samples collected, the analyses requested, location, rationale, and field measurements. The sample locations are illustrated on Figures 1-5 and the analytical results are summarized in Tables 1-8.

Analyses were performed by the EPA Contract Laboratory Program (CLP) Routine Analytical Services (RAS) and Unique Laboratory Sample Analyses (ULSA). All sample results are included in Appendix D: Validation Reports and Laboratory Data Forms.

The DMG sampling activities in Cement Creek included the collection of 102 samples, including 43 surface water, 14 aqueous sources (draining mines) and 45 solid source (mine dump) characterization, and 4 duplicate samples. Appendix B, Tables I-IV, list the samples collected, the analyses requested, location, rationale, and field measurements. Analytical results are summarized in Tables 2-6, herein. DMG aqueous sample analyses, conducted by the EPA lab in

Denver, were

analyzed for total and dissolved metals (Tables 2, 4 & 5). The solid source field leachate (diluted with 3x volume of water, agitated, let stand for a minimum of two hours, then leachate decanted) samples were analyzed in the field for ph, specific conductivity, total acidity and sulfate. Lab analyses of the decanted leachate were conducted by the Colorado School of Mines laboratory for total metals. Results are presented in Appendix C.

Flow measurements were obtained for most surface water locations and mine drainages. Global Positioning (GPS) readings were taken for all sample locations. Metals loading calculations were performed for each aqueous sample where flow measurements were obtained (Table 6).

## **2.0 SITE DESCRIPTION**

This investigation encompasses Cement Creek and its tributaries: Prospect Gulch, North Fork, Middle Fork, Minnehaha Creek and the South Fork of Cement Creek. The City of Silverton is situated at an elevation of 9,305 feet above mean sea level (M.S.L.). Cement Creek originates about seven miles north and west of Silverton, near the San Juan County line at approximately 13,000 feet above M.S.L. Historic mining in the area took place throughout Prospect Gulch and Cement Creek Basins.

The discovery of gold in Arrastra Gulch brought miners to the Silverton area in the early 1870's. The discovery of silver in the base-metal ores was the major factor in establishing Silverton as a permanent settlement. Between 1870 and 1890, the richer ore deposits were discovered and mined to the extent possible. Not until 1890 was any serious attempt made to mine and concentrate the larger, low-grade ore bodies in the area. The North Star mine constructed a mill on Sultan Mountain (approximately 1 mile southwest of Silverton) and between 1894 and 1897; a nearby matte smelter processed up to 100 tons of ore per day (CDH, 1994a).

The Kendrick and Gelder (K&G) smelter was built near the mouth of Cement Creek in 1900 and operated during the summer months until 1905. Regional low-grade ores containing gold, silver, lead and zinc were processed at 12 concentration mills in the valley, and further refined at the K&G smelter. Approximately 5,500,000 pounds of copper matte from the upper levels

of the Henrietta mine, located in Prospect Gulch, were generated at the K&G smelter. The K&G Smelter was operated by the Ross Mining and Milling Company in 1906 and 1907, chiefly for copper ores from its mines. Mining and milling slowed down around 1905, and mines were consolidated into fewer larger operations with the facilities for milling large volumes of ore (CDH, 1994a).

The Cement Creek basin contains many historic mines. The Queen Anne Mine, Ross Basin (unnamed) Mines, Mogul Mine, South Mogul Mine, and the Red and Bonita Mine are located in upper Cement Creek Basin. The Sunnyside Gold Company's Sunnyside Mine, located approximately 5.5 miles up Cement Creek near Gladstone, began operations in 1959, mining copper, lead, zinc, silver and gold. The Gold King Mine complex is located in the North Fork of Cement Creek. The Lead Carbonate Mill is located in the Minnehaha Creek basin. The Black Hawk Mine is located in the Middle Fork, whereas the Silver Ledge Mine is located in the South Fork. (DMG, 1995a&b).

A Preliminary Assessment was conducted on the Kendrick & Gelder Smelter by the Colorado Department of Health in 1994 (CDH, 1994a). Site Investigations and related surface water sampling was conducted at both the Sunnyside Mine at Gladstone, in Cement Creek Basin, as well as at the Mayflower Mill, located approximately 1.5 miles north of Silverton, by the CDH in 1984. Surface water sampling of Cement Creek, fifty feet above and below the Sunnyside Mine, above the confluence with South Fork, indicated concentrations of heavy metals including cadmium, lead and silver, above drinking water standards (CDH, 1984a&b).

Prospect Gulch and Cement Creek were included in the *Animas River Targeting Project*, initiated by the CDPHE Water Quality Control Division in 1991. The project consisted of monitoring the chemical, physical and biological health of the Upper Animas River Basin to determine what improvements to aquatic life uses might be attained. Synoptic water quality monitoring at 200 sites within the Upper Animas, Cement and Mineral Creek basins was conducted on four occasions: September, 1991; June 1992; October 1992; and July 1993.

Biological assessments, conducted at selected sites in the upper basin in October, 1992, found that aquatic life is not supported in the Cement Creek basin (as well as in Animas River above Maggie Gulch, and the mainstem and Middle Fork of Mineral Creek). Lack of aquatic life is attributable to both natural and anthropogenic factors contributing to dissolved aluminum, cadmium, copper, and zinc present in the Animas River basin at concentrations acutely and chronically toxic to most forms of aquatic life. Additionally, ferric iron, coming from Cement Creek (and Mineral Creek) forms a deposit on the Cement Creek stream bed as well as in the Animas River between Cement Creek and Elk Creek, further inhibiting aquatic life (CDPHE, 1994).

The Bureau of Reclamation conducted Fish Tissue Analyses as part of their 1992 *Animas River Toxicity Study*. Fish were collected from the Animas River from approximately 1/4 mile above Elk Creek (approximately 6 miles below Silverton) to the Colorado/New Mexico State line in April, 1992 and analyzed in June of 1992. Results of this study were included in the October, 1995 *Animas Discovery Report* prepared by CDPHE for EPA (CDPHE, 1995b).

During September-October, 1994, the U.S. Geological Survey, in cooperation with the CDPHE analyzed drainage from natural springs for comparison with mine drainage, in Ohio and Topeka Gulches, tributaries to Cement Creek. Mines had similar concentrations and loads of dissolved metals compared to naturally occurring springs and streams in Topeka Gulch (USGS, 1995).

Sunnyside Gold Corporation (SSG) has been monitoring both natural seeps and mine drainages (the Mogul, South Mogul, Red & Bonita, Black Hawk and Silver Ledge Mines) near the Sunnyside Mine (American Tunnel) in preparation to seal the American and Terry Tunnels. The sites have been monitored during high flow (June/July) and low flow (September/October) for flow and dissolved copper, iron, lead, manganese and zinc prior to plugging the portals for comparison to post-closure water quality.

As a component of plugging the portals, SSG would like to terminate Colorado Discharge Permit System (CDPS) Permits Numbered CO-0027529 (American T.) and CO-0036056 (Terry T.). SSG has reached an agreement with the CDPHE wherein SSG will treat a portion of Cement Creek streamflow until the mine pool has reached equilibrium, and mitigate 6 mine sites in an effort to maintain water quality in the Animas River at a point below the confluence with Mineral Creek (reference point). SSG will monitor (monthly) and treat any remaining flow from the American and Terry Tunnels as well as Cement Creek both above and below treatment until treatment ceases; seeps and adits during high and low flow; receiving streams above and below any water flowing from four of the six mitigation projects (four times a year, at least one at high flow and at least two at low flow) for one year prior to and two years following remediation; and every other month at the Animas River above its confluence with Cement Creek; Cement Creek above its confluence with the Animas River; Mineral Creek above its confluence with the Animas River; and, once per month during the project period at the Animas River reference point, below the confluence with Mineral Creek.

The CDPHE will determine that there has been a "Successful Permit Termination Assessment" if: five years have elapsed from the date of valve closure at the American T. property-line plug; and, two years have elapsed since mine pool equilibrium has been reached; and, valves and pipes in the seal in the American and Terry Tunnels have been grouted and hydrologic control and seals eliminating flows from the lower American Tunnel Portal have been completed or water treatment at the American T. has been accepted by another party or parties; and, the six mitigation sites have been completed; and, treatment of Cement Creek has ceased; and, that the reference water quality is being maintained without continued treatment of Cement Creek (District Court, 1996).

### **3.0 DATA VALIDATION AND INTERPRETATION**

The laboratory acquired data were validated by the EPA Environmental Services Assistance Team

(ESAT). Validation reports and laboratory data forms can be found in Appendix D. The analytical results, qualifiers, and interpretations are presented in Tables 1,3,6 & 8. The following data qualifiers were assigned:

- "U" - The analyte was not detected. (Qualified by laboratory software).
- "J" - The assigned value is an estimate because the quality control criteria were not met.
- "UJ" - The analyte was not detected and the reported value is estimated because the quality control criteria were not met.
- "B" "BD" - The analyte was detected at a level below the contract required detection limit (CRDL) but above the method detection limit (MDL), therefore the associated value is an estimate. The presence of the compound is reliable.
- "BJ" - The value is estimated because the analyte was detected at a concentration below the CRDL and because the quality control criteria were not met.
- "R" - The data are rejected.
- "NA" - Indicates that the analyte was not sampled/analyzed for.

Mercury results were rejected for the mine dump samples, as holding times were exceeded.

Analytes present at "elevated" concentrations are highlighted in the summary tables. A concentration is considered to be "elevated" if the following are true:

- The concentration of a particular analyte in a sample is three times greater than the background concentration; and greater than or equal to five times any blank sample concentrations.
- If the analyte is not detected in the background sample, the concentration is greater than the sample quantitation limit for both the sample and the background sample.

#### **4.0 SOURCE CHARACTERISTICS**

##### **4.1 Solid Source Samples**

A total of 15 solid source samples were collected by CDPHE from major mine waste dumps located throughout the study area along Cement Creek, Prospect Gulch and their tributaries. The 15 solid source samples were collected from the largest mine dumps in the district. The samples were collected from 0-6 inches below the ground surface for most sources. Sample locations are illustrated on Figures 2 through 4. The samples were analyzed for total metals and the results are summarized in Table 1. DMG filed leachate and laboratory analytical results of 45 solid source samples are presented in Appendix C.

These data show that large volumes of source material containing high metals concentrations are available for release to surface waters.

#### **4.2 Aqueous Source Samples**

DMG collected 14 aqueous source samples from draining mines in the basin. These samples were analyzed for total and dissolved metals; total metals are presented in Table 2; total and dissolved metals are presented in Appendix C. The results indicate that all of the adits exhibit high concentrations of several analytes. The rate of discharge from these sources ranges from 1% to 50% of the flow in the receiving streams.

### **5.0 SURFACE WATER PATHWAY**

Previous studies have documented the release of metal contaminants to surface water in Cement Creek, Prospect Gulch and tributaries, and the Animas River. Primary targets within 15 downstream miles of known sources include fisheries, wetlands, and threatened and endangered species habitats.

Cement Creek, including all tributaries, from the headwaters to its confluence with the Animas River are classified for recreation 2 and agriculture. The Animas River from a point immediately above the confluence with Cement Creek to a point immediately above the confluence with Mineral Creek is classified as recreation 2. Existing ambient metals standards (as of February 15, 1995)

for these stream segments have been adopted by the Colorado Water Quality Control Commission (WQCC) until further consideration, scheduled for 2001.

Cement Creek, Prospect Gulch and tributaries are devoid of fish due to metals loading. Minimal aquatic life is supported in the Animas River from its confluence with Cement Creek to Elk Park, located approximately 6 miles downstream of Silverton (CDPHE, 1995).

Silverton obtains its municipal drinking-water from Boulder Creek, a tributary to the Animas River, located approximately 1 mile north of the Cement Creek Confluence with the Animas River, and up gradient of the Sunnyside Gold Mill tailings (CDPHE, 1995b).

Federally listed endangered species habitat that could occur at or visit the area include the Northern Goshawk (*Accipiter gentilis*) and the Boreal Toad (*Bufo borealis*) (USFWS, 1995).

Numerous large mine waste rock piles and smaller tailings pile sources have been identified throughout the basin which are uncontained with respect to the surface water pathway. In addition, numerous draining mine adits discharge into the receiving streams in the basin.

## **5.1 Surface Water and Sediment Sample Locations**

Sample locations are illustrated on Figures 1-4. Appendix A, Tables I and II, and Appendix B, Tables I-IV, provide a summary of the samples collected and the analyses performed. A total of 45 aqueous (SW) and collocated sediment (SE) surface water samples were collected for this investigation by DMG and CDPHE, respectively. All aqueous samples were analyzed for total and dissolved metals. All sediment samples were analyzed for total metals. Six pairs (SW and SE) of surface water samples were analyzed for organics and cyanide; six surface water samples were also analyzed for Total Organic Carbon (Table 3).

## **5.2 Surface Water and Sediment Analytical Results**

Surface water analytical results are summarized in Tables 3 through 6. Dissolved (Table 5) and

total (Table 4) metals results for aqueous surface water samples compare favorably, i.e. total concentrations generally exceed dissolved concentrations. Table 7 presents the total metals concentrations for sediment samples. Table 3 presents the surface water and sediment organic analytes. "Elevated" concentrations (as defined in section 3.0) are highlighted in the tables.

High concentrations of metals were detected in the headwaters of Cement Creek, increasing noticeably following the introduction of mine drainage from the Queen Anne and Ross basin draining mines. Metals concentrations decrease as Cement Creek progresses downstream, especially notable following treatment of the American Tunnel and a portion of Cement Creek by Sunnyside Gold Corporation. Loading tends to increase as Cement Creek flows downstream, however, with obvious pulses of increased loading below the Queen Anne Mine, Mogul and South Mogul Mines, Red & Bonita Mine, locations below the American Tunnel, below the confluence with South Fork, below the confluence with Dry Gulch, below the confluence with Prospect Gulch and below the confluence with Georgia Gulch.

As identified in Table 4, total concentrations of aluminum, copper, iron, lead, manganese and zinc in Cement Creek were "elevated", i.e., three times greater than background for every downstream sampling location. Total concentrations of aluminum, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, nickel and zinc below the Gold King Mine were elevated above background in the North Fork of Cement Creek. Total metal concentrations of both downstream locations in the South Fork of Cement Creek, i.e., below the Silver Ledge and Big Colorado Mines, were elevated above background for aluminum, cadmium, cobalt, copper, iron, lead, manganese, and zinc.

Table 6 contains total metal loading in Cement Creek for aluminum, cadmium, copper, iron, lead, manganese and zinc. A series of Bar Graphs, Figures 6-27, graphically present total loadings calculations for these analytes, comparing them to stream acidity and sediment concentrations in each location.

Metals Loading analyses, presented in Table 6 and Figures 9, 13, 15, 19, 23, 25 and 27 reveal that the mines in the upper basin, i.e., the Queen Anne, Henrietta and Mogul Mines, contribute significantly to the metal loadings in upper Cement Creek. Mines in the Lower Basin, however, contribute only a small portion to the increasing metals loadings in Cement Creek as it flows toward the Animas River, except for a pulse of increased loading below Georgia Gulch, where the Kansas City Mines are located.

The discharge from the American Tunnel as well as flow from Cement Creek at the American Tunnel is actively treated by Sunnyside Gold Corporation. The treated tunnel discharge and creek waters are returned to the Cement Creek channel immediately above sample location CC-SW/SE-24. The American Tunnel drainage was not sampled. The treatment of the American Tunnel causes a drastic rise in pH at the sampling location immediately downstream. Total iron, lead and manganese loadings significantly increase at this location.

Total metal concentrations of all downstream locations in Prospect Gulch were elevated above background for aluminum, cobalt, copper, iron, lead, manganese, and zinc, increasing in pulses following: introduction of the Galena Queen Mine in the headwaters; the confluence with tributaries contributing acid rock drainage; and, after the introduction of the Henrietta mine.

Cadmium, copper and zinc loadings increase in the upper basin, remain constant throughout the middle and lower basin, while slightly decreasing between the treatment of the American Tunnel/Cement Creek (CC-SW-33) and the confluence with Prospect Gulch (CC-SW-26), and increasing below Gorgia Gulch and the Kansas city mines. Loading of aluminum, iron, lead and manganese increases as Cement Creek progresses downstream, with notable increases downstream of the American Tunnel/Cement Creek treatment location (CC-SW-33), as well as below the confluence with Prospect Gulch (CC-SW-26), and below Gorgia Gulch (CC-SW-29).

Review of Figures 9, 10, 11, 13, 15, 19, 20, 21, 23, 25 and 27, indicate that in the upper Cement Creek basin, the draining mine sources contribute significantly to the metal loadings, as the draining mines constitute as much as 50% of the flows measured in the receiving streams. As the flows increase downstream, however, metal loading contribution from the draining mine sources appears to be insignificant, although metals loading continues to increase.

Metals loadings increase as Prospect Gulch progresses downstream, with significant increases calculated below the Galena Queen Mine, below the mineralized tributaries, and again below the Henrietta Mine complex.

As generally depicted in these graphs, there is a positive correlation between stream acidity and metals loading in the surface water, negatively correlated to the sediment concentrations. This is especially noticeable in Cement Creek below Gladstone, following the treatment of the American Tunnel and a portion of Cement Creek, where draining mine contribution to the increased metal loading is insignificant. It may be interpreted that as stream acidity increases, metals in the sediment are mobilizing into the surface water column, increasing the metal loading in the surface water, consequently decreasing metals concentrations in the sediments. Naturally mineralized areas as well as non-point sources of pollution, i.e., potential mineral contribution from water contacting mine waste piles, may also contribute to metal loading.

For aquatic life, the primary metals of concern are cadmium, lead, and zinc. These metals are widespread and are frequently present at concentrations which greatly exceed the Ambient Water Quality Criteria for surface waters found in the Superfund Chemical Data Matrix (SCDM) (Cadmium 1.1, Lead 3.2, and Zinc 110, values in micrograms per liter).

As presented in Table 7, "elevated" concentrations in sediment samples were observed for antimony and magnesium downstream of the background sample to a location below Corkscrew Gulch and the ferricrete deposit on the mainstem of Cement Creek (SE-8). Vanadium is elevated for most of the downstream sampling locations. Mercury was measured at above detection, and therefore elevated compared to background below the Red & Bonita Mine (SE-9). Antimony and zinc become elevated at the locations immediately below the confluence with Dry Gulch (SE-25) and below the confluence with Prospect Gulch (SE-26). Copper is elevated in Cement Creek below the confluence with Dry Gulch (SE-25). Elevated metals concentrations for sediment samples occurred at a lower frequency than that of aqueous samples,

All surface water and sediment samples analyzed for cyanide were found to be non-detect. Surface water samples analyzed for organics were found to be non-detect, except that Methylene chloride was found at low levels (2ug/L) in two surface water samples (CC-SW-24, Cement Creek below the confluence with South Fork and PG-SW-03, Prospect Gulch below the Galena Queen Mine) and three of the rinsate samples; one surface water sample contained a low concentration of acetone (CC-SW-24 @ 3ug/L). Three sediment samples were also found to contain low concentrations of methylene chloride (CC-SE-06, Cement Creek below the Mogul Mines @ 4ug/kg; CC-SE-12, the North Fork of Cement Creek below the Gold King Mine @ 4ug/kg; and CC-SE-24, Cement Creek below the confluence with South Fork @10ug/kg); one sediment sample was found to contain low

concentrations of acetone (CC-SE-24 @ 7 ug/kg). Organic compound analytical results are presented in Table 3.

Methylene chloride and acetone are common laboratory contaminants. Methylene chloride is widely used by consumers, of which about 30% of the annual production (300,000 tons) is used in paint strippers and removers, with another 20% used in aerosol finishes, often in hairspray. EPA standard for drinking water is 150 ug/L; FDA standards for foods are: 10,000 ppb in decaffeinated coffee; 30,000 ppb in spice extracts; and, 220,000 ppb in brewing hops. OSHA limit in the workplace air is 100,000 ppb. (Harte, et.al., 1991).

Acetone is a widely used industrial solvent, and commonly used in the home in the form of fingernail polish remover, and glue. It is used in the production of lubricating oils, other industrial chemicals such as chloroform and acrylics. Nearly half of all acetone manufactured is used to make acrylic plastics. The FDA limits in spice extracts is 30,000 ppb. OSHA limit in the workplace is 750,000 ppb. Acetone can be smelled by most people when concentration in the air reaches 500,000 ppb; a concentration of 20,000,000 ppb in the air is considered dangerous (Harte, et. al., 1991).

### 5.3 Surface Water Analytical Results by Stream Segment

#### 5.3.1 Upper Cement Creek (SW/SE-01 through SW/SE-9)

As illustrated in Tables 4-5, the Upper Cement Creek surface water sample below the Queen Anne Mine (CC-SW -2) exhibited elevated concentrations of total and dissolved aluminum, cadmium, copper, manganese, nickel, and zinc, compared to the background surface water sample (CC-SW-1). Table 7 presents sediment samples at this location (CC-SE-2) exhibiting elevated concentrations in antimony, magnesium and vanadium, when compared to the background sediment sample (CC-SE-1). As shown in Table 6 the Upper Cement Creek surface water sample below the Queen Anne Mine (CC-SW -2) exhibited increased loading of total aluminum, barium, cadmium, copper, iron, lead, manganese, nickel, and zinc, compared to the background surface water sample (CC-SW-1).

The Ross Basin tributary surface water sample below the Unnamed Mine (CC-SW-4) exhibited elevated concentrations of dissolved aluminum; dissolved cadmium; dissolved and total copper, dissolved and total iron; dissolved lead; dissolved and total manganese; and dissolved and total zinc, when compared to the background sample (CC-SW-3). The Ross Basin tributary sediment sample below the Unnamed Mine (CC-SE-4) exhibited elevated concentrations of antimony when compared to the background sample (CC-SW-3), where antimony was not detected. The Ross Basin tributary surface water sample below the Unnamed Mine (CC-SW-4) exhibited increased loading of total aluminum, cadmium, copper, iron, manganese and zinc, when compared to the background sample (CC-SW-3). It is interesting to note that sediment concentrations of barium, beryllium, cadmium, copper, lead, magnesium, manganese, nickel, thallium and zinc decreased when compared to sediment concentrations measured in the background sample (CC-SE-3).

The surface water sample above the Mogul Mines (CC-SW-5) exhibited elevated concentrations in total and dissolved aluminum, cadmium, copper, manganese and zinc and total iron and lead, as well as dissolved sodium when compared to the background sample (CC-SW-1). The sediment sample above the Mogul Mines (CC-SE-5) exhibited elevated concentrations of total antimony, magnesium and vanadium when compared to the background sample (CC-SE-1). Loading at CC-SW-5 is the sum of loading measured at CC-SW-2 and CC-SW-4 plus an unknown contributing source, causing an increased loading of total aluminum, barium, cadmium, copper, iron, lead, manganese, and zinc. It is interesting to note that sediment concentrations of arsenic, barium, beryllium, cadmium, lead, and zinc decreased when compared to sediment concentrations measured in the background sample (CC-SE-1).

The surface water sample below the Mogul Mines (CC-SW-6) exhibited elevated concentrations in total and dissolved aluminum, cadmium, copper, manganese and zinc, as well as total iron, and lead, and dissolved sodium when compared to the background sample (CC-SW-1). Total Organic Carbon was measured at less than 1 mg/L at this location. Surface water and sediments at this location were analyzed for organic compounds. Methylene chloride was the only organic compound found in measurable concentrations (4ug/kg) in the sediment sample. No organic compounds were detected in the surface water sample.

The sediment sample below the Mogul Mines (CC-SE-6) exhibited elevated concentrations of total antimony, magnesium and vanadium when compared to the background sample (CC-SE-1). Loading at CC-SW-6 is the sum of loading measured at CC-SW-5 and SO-5, the Mogul Mine drainage, plus an unknown contributing source, causing an unaccounted increase in loading of total aluminum, barium, cadmium, copper, manganese, and zinc. It is interesting to note that sediment concentrations of copper, lead, and manganese decreased when compared to sediment concentrations measured in the immediate upstream sample (CC-SE-5).

The surface water samples above (CC-SW-7) and below (CC-SW-8) the confluence with Corkscrew Gulch and the Ferricrete deposit exhibited elevated concentrations in total and dissolved aluminum, cadmium, copper, iron, lead, manganese and zinc, as well as dissolved sodium when compared to the background sample (CC-SW-1). The sediment sample above Corkscrew Gulch and the Ferricrete deposit (CC-SE-7) exhibited elevated concentrations of total magnesium and vanadium when compared to the background sample (CC-SE-1). The sediment sample below Corkscrew Gulch and the Ferricrete deposit (CC-SE-8) exhibited elevated concentrations of total antimony and vanadium when compared to the background sample (CC-SE-1). Loading at CC-SW-7 and CC-SW-8 generally remained constant or exhibited minor decreases when compared to the immediate upstream sample (CC-SW-6). The same trend was observed in the sediment concentrations at these locations.

The surface water sample below the Red & Bonita Mines (CC-SW-9) exhibited elevated concentrations in total and dissolved aluminum, cadmium, copper, iron, lead, manganese and zinc, as well as dissolved potassium and sodium when compared to the background sample (CC-SW-1). The sediment sample below the Red & Bonita Mines (CC-SE-9) exhibited elevated concentrations of total mercury, when compared to the background sample (CC-SE-1), where it was not detected.

This is the only location where mercury was found in sediments at a detectable concentration.

Increased loading at CC-SW-9 below the Red & Bonita mine was calculated for total aluminum, barium, cadmium, copper, iron, manganese, and zinc. It is interesting to note that sediment concentrations of all metals analyzed, with the exception of mercury, silver and sodium decreased when compared to sediment concentrations measured in the immediate upstream sample (CC-SE-8).

### **5.3.2 The North Fork of Cement Creek (SW/SE 10 and SW/SE 12) Cement Creek's Confluence with the North Fork (SW/SE-9 and SW/SE-13) and Cement Creek Below the Treatment of the American Tunnel (CC-SW-33)**

The surface water sample below the Gold King Mine (CC-SW-12), located in the North Fork of Cement Creek, exhibited elevated metal concentrations of total: aluminum, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, nickel and zinc, when compared to the background sample (CC-SW-10). Dissolved analyses were not conducted. Loading was not calculated, as flow was not measured in the background sample. The sediment sample below the Gold King Mine (CC-SE-12) exhibited elevated concentrations of antimony, arsenic, lead, selenium, and silver, when compared to the background sediment sample (CC-SE-10). Surface water and sediments at this location were analyzed for organic compounds. Methylene chloride was the only organic compound found in measurable concentrations (4ug/kg) in the sediment sample. No organic compounds were detected in the surface water sample. Total Organic Carbon was measured at 1 mg/L in the surface water sample.

The surface water sample in Cement Creek below the confluence with the North Fork (CC-SW-13) exhibited elevated concentrations of total and dissolved aluminum, cadmium, copper, iron, lead, manganese and zinc as well as dissolved chromium, nickel, sodium and vanadium, when compared to the Cement Creek background sample (CC-SW-1). The Cement Creek sediment sample below the confluence with the North Fork (CC-SE-13) exhibited elevated concentrations of vanadium when compared to the background sediment sample (CC-SE-1). Total metal loadings calculated at this location were less than those measured at the sampling location immediately upstream (CC-SW-9). The reverse trend was noted for sediment samples taken at the same locations, i.e., sediment concentrations were higher in the sample below the confluence with the

North Fork than that of the next immediate upstream sample, with the exception of mercury, silver and sodium.

The surface water sample in Cement Creek below the American Tunnel treated effluent (CC-SW-33) exhibited elevated concentrations of total and dissolved aluminum, copper, iron and manganese as well as dissolved calcium and sodium; and total lead and zinc, when compared to the Cement Creek background sample (CC-SW-1). Metal loadings downstream of the American Tunnel treated effluent either increased or decreased by the following amounts, compared to the immediate upstream sample (CC-SW-13): aluminum increased by 16%; barium increased by 24%; cadmium decreased by 48%; copper decreased by 73%; iron increased by 610%; lead increased by 408%; manganese increased by 595%; and zinc decreased by 33%. The American treated effluent was not analyzed; therefore, contribution from the Tunnel was not able to be determined. It is of interest to note that with exception of cadmium, calcium and selenium, total metal concentrations of the sediment sample below the American Tunnel were 33%-50% less than that measured at the sampling location immediately upstream (CC-SW-13), perhaps accounting for some of the increased loading. Calcium concentrations increased by 232%.

**5.3.3 Cement Creek's Confluence with the South Fork (CC-SW/SE-33 and CC-SW/SE-24);  
South Fork of Cement Creek (CC-SW/SE-21 through CC-SW/SE-23) and tributaries:  
Minnehaha Creek (CC-SW/SE-14 and CC-SW/SE-15)  
Middle Fork of Cement Creek (CC-SW/SE-17 through CC-SW/SE-20) and  
Cement Creek below the confluence with Dry Gulch (CC-SW-25)**

The background surface water sample above the Lead Carbonate Mill (CC-SW-14), located in **Minnehaha Creek**, tributary to the South Fork of Cement Creek, was unable to be sampled as it was dry; the sampling team decided not to collect a sediment sample there as well. However, total and dissolved metals concentrations in the surface water sampled below the Lead Carbonate Mill (CC-SW-16) were high for aluminum; cadmium; copper; iron; the highest concentration of total and dissolved lead of all the surface water sampled; manganese and zinc. The surface water sample below the Lead Carbonate Mill (CC-SW-16) exhibited decreased total and dissolved metal concentrations and loading of total metals, with the exception of total cobalt, when compared to the sample immediately upstream (CC-SW-15).

The sediment samples taken below the Lead Carbonate mine at the mouth of Minnehaha Creek, above its confluence with the South Fork (CC-SE-16), exhibited elevated concentrations of

aluminum, beryllium; cobalt; magnesium; manganese; nickel; selenium and vanadium, when compared to the sediment sample taken below the Lead Carbonate Mill (CC-SE-15), where beryllium and selenium were not detected.

The background surface water sample above the Black Hawk Mine (CC-SW-17), located in **Middle Fork**, tributary to the South Fork of Cement Creek, was unable to be sampled, as it was dry; a sediment sample was collected at this location, however. Total and dissolved metals concentrations in the surface water sampled below the Black Hawk Mine (CC-SW-19) were high for iron, manganese and zinc. Sediment concentrations measured below the Unnamed Waste Rock Pile (CC-SE-18) and below the Black Hawk Mine (CC-SE-19) decreased relative to the background sample (CC-SE-17).

The surface water sample at the mouth of Middle Fork, before its confluence with South Fork, (CC-SW-20) exhibited relatively similar or decreasing concentrations of total and dissolved metals compared to the immediate upstream sample (CC-SW-19). With the exception of calcium and zinc, the sediment sample at this location also exhibited decreasing concentrations of total metals when compared to the background sample (CC-SE-17).

The surface water sample below the Big Colorado and Silver Ledge Mines (CC-SW-22), located in the **South Fork of Cement Creek**, exhibited elevated metal concentrations of total and dissolved aluminum, cadmium, iron, manganese and zinc; dissolved calcium and magnesium; and total cobalt, copper, lead and vanadium when compared to the background sample (CC-SW-21). Loadings calculated at CC-SW-22 ideally encompass the effects of loadings from the background sample, CC-SW-21, plus drainage from the Silver Ledge (SO-13) and Big Colorado (SO-17) Mines. Aluminum and copper loadings, however, are twice the sum of known contributors, and cobalt loadings are 25% greater than the sum of the parts. Loadings of iron, manganese and zinc, however, were less than the sum of the known contributors. Interesting to note, manganese and zinc concentrations in the sediment at CC-SW-22 were also lower than the background sample (CC-SE-21). The remaining metals concentrations in the sediments were higher at this location compared to background.

The surface water sample in South Fork above its confluence with the mainstem of Cement Creek (CC-SW-23) exhibited elevated metal concentrations of total and dissolved aluminum, cadmium, cobalt, copper, iron, manganese and zinc; dissolved calcium, chromium, magnesium, potassium, and vanadium; and total lead when compared to the background sample (CC-SW-21). Loadings

calculated at CC-SW-23 ideally encompass the effects of loadings from the immediate upstream sample, (CC-SW-22), the mouth of Minnehaha Creek (CC-SW- 16) and the Middle Fork (CC-SW-20). The flow measured at CC-SW-23 is 14% greater than the sum of the contributing tributaries.

Manganese and zinc loadings, however, are twice the sum of known contributors, cadmium 69% greater, aluminum and cobalt 38% greater, copper 28% greater and barium and lead 19% greater than the sum of known contributors. Iron was 20 % less than the sum of contributors. Interestingly, sediment concentrations of the those metals for which increases in loading at CC-SE-23 were unaccounted for, are considerably lower than the concentrations measured at the mouth of Minnehaha and Middle Fork: aluminum is 50 % lower; barium is ranges between 25 - 45% lower; cadmium is undetected whereas it is measured in the upper samples; cobalt is 80% lower; copper is between 75-80 % lower; lead is between 60-75% lower; manganese is 68-78% lower; and zinc is an order of magnitude less than the sediment concentrations at the upper locations. The decrease in sediment concentrations may account for the unidentified loading contributions.

The surface water sample in **Cement Creek below the confluence with the South Fork** (CC-SW-24) exhibited elevated concentrations of total and dissolved: aluminum, cobalt; copper; iron; and manganese; dissolved calcium, potassium, sodium; and total lead and zinc compared to the Cement Creek background sample (CC-SW-1). Metals loading at this location ideally combine the sum of loadings calculated at the immediate upstream sample (CC-SW-33) plus the contribution from South Fork (CC-SW-23). Although the flow measured at CC-SW-24 is 8% greater than the sum of the two contributors, loadings are generally 10 to 25% less than the combined sum; conversely, sediment concentrations in the downstream sample are generally greater than the average of the two upstream samples. This sediment sample location exhibited elevated vanadium concentrations than the background (CC-SE-1)

Surface water and sediments at this location were analyzed for organic compounds. Methylene chloride and acetone were the only organic compounds found in measurable concentrations (10 and 7 ug/kg, respectively) in the sediment sample. Methylene chloride was also found in the surface water sample at the low concentration of 2 ug/L. Total Organic Carbon was also measured at less than 1 mg/L in the surface water sample. Cyanide was not detected.

The surface water sample in **Cement Creek below the confluence with Dry Gulch (CC-SW-25)** exhibited elevated concentrations of total and dissolved aluminum, cobalt, copper, iron, lead, and manganese; dissolved calcium and sodium; and total zinc when compared to the background

sample (CC-SW-1). Loading calculations for CC-SW-25 should combine contributions from the immediate upstream sample (CC-SW-24), the Dry Gulch Adit (SO-24) and Dry Gulch (not sampled). Although the Flows at CC-SW-25 were 25% greater than the upstream sample, loading calculations for total

metals increased by the following: aluminum increased by 222%; barium and cadmium increased by 35%; cobalt increased by 98%; copper increased by 17%; iron increased by 296%; lead increased by 256%; manganese increased by 47%; and zinc increased by 60%. Sediment concentrations for antimony, copper, vanadium and zinc were elevated at this location, relative to the background sample (CC-SE-1).

#### **5.3.4 Prosect Gulch (PG-SW/SE-1 through PG-SW/SE-19) and Cement Creek's Confluence with Prospect Gulch (CC-SW/SE-26 through CC-SW/SE-38)**

The surface water sample below the Galena Queen Mine (PG-SW-3), located in the headwaters of Prosect Gulch, a tributary to Cement Creek, exhibited elevated metal concentrations of total and dissolved aluminum, arsenic, cadmium, cobalt, copper, iron, lead, manganese, nickel and zinc, when compared to the background sample (PG-SW-1). Loadings of these same metals increased significantly as well. The sediment sample below the Galena Queen Mine (PG-SE-3), exhibited elevated concentrations of antimony, arsenic, cadmium, copper, lead, mercury, silver, sodium, thallium and zinc, compared to the background sediment sample (PG-SE-1) where antimony, mercury and silver were not detected.

Surface water samples at this location were analyzed for organic compounds. Methylene chloride and acetone were found in low concentrations (@ 3ug/L); these compounds were not analyzed for in the background sample. Cyanide was analyzed and found to be below detection. Total Organic Carbon was measured at 2 mg/L in the surface water sample at this location.

Sediments at PG-SE-4, a tributary to Prospect Gulch were analyzed for organic compounds, yet not detected. Cyanide was detected at a low concentration of 0.14 mg/kg.

The surface water sample below the four mineralized tributaries (PG-SW-8), located in the headwaters of Prosect Gulch, exhibited elevated concentrations of total and dissolved aluminum, cadmium, cobalt, copper; iron, lead, manganese, and zinc; and dissolved calcium, when compared to the background sample (PG-SW-1). With the exception of iron, metal loadings increased at this

location, when compared to the immediate upstream sample (PG-SW-3). The sediment samples below the mineralized headwater tributaries (PG-SE-8), exhibited elevated concentrations of beryllium, lead, silver and zinc, compared to the background sediment sample (PG-SE-1) where silver was not detected.

The surface water sample below the mineralized tributary, and above the Henrietta Mine (PG-SW-11), exhibited elevated surface water concentrations for total and dissolved aluminum, cadmium, copper, iron, lead, manganese and zinc, and dissolved calcium, cobalt, and nickel when compared to the background sample (PG-SW-1). Metal loadings decreased when compared to the immediate upstream samples (PG-SW-9 and 10). Sediment concentrations of antimony lead and silver were elevated relative to the background sample; with the exception of aluminum, arsenic, copper and zinc, the sediments at this location exhibited increases in total metals concentrations when compared to the immediate upstream sample (PG-SE-9).

The surface water sample below the Henrietta Mine (PG-SW-16), exhibited elevated surface water concentrations for total and dissolved aluminum, cadmium, cobalt, copper, iron, lead, manganese, nickel and zinc; total arsenic; and dissolved calcium and magnesium when compared to the background sample (PG-SW-1). With the exception of barium, metal loadings significantly increased when compared to the immediate upstream samples (PG-SW-11). Sediment concentrations exhibited only slight increases in concentration, if any, when compared to the immediate upstream sample (PG-SE-11); sediment concentrations of cadmium, lead and silver were elevated when compared to background.

Surface water and sediments at this location (PG-SW/SE-16) were analyzed for organic compounds. Organic compounds were not detected in either the surface water or sediments at this location. Total Organic Carbon was measured at less than 1 mg/L in the surface water sample at this location. Cyanide was not detected in either the surface water or sediments.

The surface water sample below the Joe & John's Mine (PG-SW-18), exhibited elevated surface water concentrations for total and dissolved aluminum, cadmium, cobalt, copper, iron, lead, manganese, nickel and zinc; total arsenic; and dissolved calcium and magnesium, when compared to the background sample (PG-SW-1). Metal loadings slightly decreased when compared to the immediate upstream samples (PG-SW-16), perhaps reflecting dilution from the two tributaries entering Prospect Gulch between the two sampling locations. Sediment concentrations of total aluminum, antimony, chromium, cobalt, iron, manganese, nickel, and potassium exhibited only slight increases in concentration, if any, when compared to the immediate upstream sample (PG-SE-11),

whereas the remaining metals exhibited decreasing concentrations. Sediment concentrations of antimony, lead and silver were elevated when compared to background.

Surface water was not sampled at the mouth of Prospect Gulch, before its confluence with Cement Creek. A sediment sample (PG-SE-19) was collected, however, and exhibit elevated lead and silver concentrations when compared to the background sample (PG-SE-1). Arsenic, iron, vanadium and zinc sediment concentrations were considerably higher at this location when compared to the immediate upstream sample (PG-SE-18); the remaining metals were relatively similar.

The surface water sample in Cement Creek below the confluence with Prospect Gulch (CC-SW-26) exhibited elevated concentrations of total and dissolved aluminum, copper, iron, lead, manganese and zinc; total arsenic, chromium and cobalt; and dissolved calcium, and sodium when compared to the Cement Creek background surface water sample (CC-SW-1). Although the flow increased by only 9% at this location, loadings of total aluminum and cobalt increased by 200%, total copper loading increased by 62% and total iron loading increased by 238%, relative to the upstream sample (CC-SW-25). Significant increases in sediment concentrations of total aluminum, cobalt, copper, and iron were exhibited at this location (CC-SE-26), when compared to the immediate upstream sample (CC-SE-25); the remaining metals were relatively similar between the two samples. Sediment concentrations were elevated for total antimony, vanadium and zinc, when compared to the background sample (CC-SE-1).

The surface water sample in Cement Creek below the confluence with Georgia Gulch (CC-SW-28) exhibited elevated concentrations of total and dissolved aluminum, arsenic, cobalt, copper, iron, lead, manganese, nickel and zinc; and dissolved antimony, beryllium, calcium, magnesium, and sodium compared to the Cement Creek background surface water sample (CC-SW-1). Metals loading of aluminum, arsenic, barium, cobalt, iron, lead, manganese and zinc are significantly greater at this location than at the immediate upstream sample (CC-SW-26), and appears to be much greater than the contributions attributed to the Prospect Gulch adit (SO-18) and the Kansas City Mine (SO-20). Georgia Gulch was not sampled to determine its contribution to the loading at this location. With the exception of manganese and zinc sediment concentrations, which decreased by approximately 35%, metals sediment concentrations remained similar to the immediate upstream sample (CC-SE-26).

The surface water sample in Cement Creek downstream of the adit below Georgia Gulch (SO-19),

below the confluence with Fairview and Minnesota Gulches, and above the confluence with Porcupine Gulch (CC-SW-29) exhibits elevated concentrations of total and dissolved aluminum, arsenic, cobalt, copper, iron, lead, manganese, vanadium and zinc; and dissolved calcium, nickel, potassium and sodium when compared to the background sample (CC-SW-1). Loadings at this location are greater than the immediate upstream sample (CC-SW-28). As Fairview and Minnesota Gulches were not sampled it was not determined what their contribution to the loading calculation may be. Sediment concentrations of metals at this location are elevated for magnesium and

vanadium. Iron and zinc concentrations at CC-SE-29 are considerably less at this location at the sample immediately upstream (CC-SE-28). Manganese, on the other hand is approximately three times higher than the upstream sample. The remaining metals sediment concentrations are similar or slightly greater than the sediments concentrations in the immediate upstream sample.

The surface water sample in Cement Creek below the confluence with Porcupine Gulch (CC-SW-31) exhibited elevated concentrations of total and dissolved aluminum, arsenic, copper, iron, lead, manganese and zinc; and dissolved beryllium, calcium, nickel and sodium; as well as total cobalt, when compared to the background sample (CC-SW-1). The flow at this location is 15% lower than the immediate upstream sample, even though Porcupine Gulch flows into Cement Creek. The majority of the total metal loadings, however, range from 20 to 25% lower than the immediate upstream sample (CC-SW-29). Sediment concentrations of chromium, copper, silver, vanadium and zinc are greater than the immediate upstream sample (CC-SE-29); the remaining sediment metals concentrations are lower than, or relatively similar to, the upstream sample.

The surface water sample in Cement Creek above its confluence with the Animas River (CC-SW-48) exhibited elevated concentrations of total and dissolved aluminum, cobalt, copper, iron, lead and manganese; dissolved cadmium, nickel, potassium, and sodium; and total arsenic and zinc, when compared to the Cement Creek background sample (CC-SW-1). The flows at this location are 51% higher than the immediate upstream sample (CC-SW-31); changes in loading relative to the immediate upstream sample range from: iron decreased by 6%; lead increased by 17%; arsenic increased by 31%; aluminum increased by 39%; cadmium increased by 49%; copper increased by 50%; manganese increased by 51%; cobalt increased by 65%; and barium increased by 86%. Sediment concentrations of vanadium were elevated compared to background (SCC-SE-1). Sediment concentrations of arsenic, barium, calcium, cobalt, iron, lead, manganese, potassium, sodium, thallium, and zinc increased relative to the immediate upstream sample (CC-SE-31). The

remaining metals were relatively similar to or slightly lower than the upstream sample.

### **5.3.5 Animas River (CC-A-SW/SE-68 and CC-A-SW/SE-72)**

The surface water in the Animas River below the Town of Silverton (CC-A-SW-72), also below the confluence with both Cement and Mineral Creeks, exhibited elevated concentrations of total aluminum, arsenic, copper, iron, and lead; and dissolved iron, when compared to the Animas River above Cement Creek (CC-A-SW-68). Loading at CC-SW-A-72 should reflect the combined sources of the Animas River above Cement Creek (CC-SW-A-68), Cement Creek (CC-SW-CC48) and Mineral Creek (CC-SW-M34). The flow at CC-SW-A-72 is approximately 3% greater than the contributing sources. Iron loadings decreased by 10%, lead loadings decreased by 8.5% and zinc loadings decreased by 5% when compared to the Animas River above Cement Creek (CC-SW-A-68). The remaining metals loadings were similar to or slightly greater than the upstream sample. Sediment concentrations for aluminum, antimony, arsenic, barium, beryllium, calcium, chromium, cobalt, iron, magnesium, manganese, selenium, and vanadium were higher at CC-SE-A-72 than the sample taken from the Animas River above Cement Creek (CC-SE-A-68). The remaining metals were similar to or slightly less than the upstream sample. Concentrations of silver at CC-SE-A-72 were elevated relative to the sample taken from the Animas River above Cement Creek (CC-SE-A-68).

## **6.0 SOIL EXPOSURE, AIR, AND GROUND WATER PATHWAYS**

The risk posed to human health or the environment by the on-site pathway for the sources identified is considered to be minimal. There are no persons living on-site or within 200 feet of any of the identified sources. The sources located along Cement Creek, Prospect Gulch and their tributaries are greater than 1-mile from the nearest residents.

The risk posed to human health or the environment by the air pathway for the sources identified is

also considered to be minimal. Although the sources located along Cement Creek, Prospect Gulch and their tributaries are uncovered and access is not restricted, these sources are located more than 1-mile from the nearest residents.

Three ground water wells and two surface water sources used for drinking water were sampled as part of this SI. One well is located in on the mainstem of the Animas River, approximately 1 mile above Howardsville (GW-3); one well is located up Cement Creek, approximately 1 mile below the confluence with Prospect Gulch (GW-1); one well is located along Mineral Creek, approximately 1

mile above its confluence with the Animas River (GW-5). Two surface water sources are used for drinking water: a summer residence utilizing filtered surface water from the Middle Fork of Cement Creek, below the Silver Ledge Mine; the other, the Lenore Load, a draining mine adit located in Cunnigham Gulch, filtered and used by vacationers in their travel trailer for two weeks each summer.

Drinking water samples were collected prior to any in-home filtration system and analyzed for total and dissolved (filtered using a 0.45 micron membrane filter) metals. Results are presented in Table 8.

Total lead concentrations in the Cement Creek Well (GW-1), and both total and dissolved lead concentrations in the Lenore Load adit (GW-4) and the Mineral Creek Well (GW-5) exceed the EPA recommended action level of 15 ug/l. The Lenore lode adit (GW-4) total and dissolved cadmium concentrations exceed EPA's recommended action level of 5ug/L. Except for the Lenore lode adit, the remaining drinking water samples had manganese concentrations ranging between 352 to 2130 ug/L; well above the current EPA Action Level of 200 ug/l. The groundwater well above Howardsville (GW-3) was the only site with manganese concentrations above the CDPHE health based advisory of 800 ug/l.

Letters have been sent to each of the drinking water users providing them with the analytical results. Retesting of each well/surface water was offered to each household, such that samples could be taken to determine the effectiveness of any in-home filtration system to remove cadmium, lead or manganese. In those instances where the lead and cadmium concentrations exceeded drinking water standards or action levels, the users were advised not to consume the water without adequate filtration.

Additionally, the letters informed the residents that recent toxicological studies indicate that concentrations of manganese in drinking water of 800 ppb or less is considered acceptable, and that although EPA has not set a primary drinking water standard for manganese, they have set a secondary drinking water standard of 50 parts per billion, based on taste rather than possible adverse health affects. In the one instance where the manganese concentration exceeded the 800 ppb health based advisory, i.e., the well located along the Animas River above Howardsville (GW-3), it was recommended that the well water not be consumed without adequate filtration. Copies of the letters sent are included in Appendix E.

## 7.0 SUMMARY AND CONCLUSIONS

Source samples collected from the major mine dumps located throughout the district indicate that large volumes of both aqueous (draining mine adits) and solid source (Mine waste piles) material containing high metals concentrations are available for release to surface waters.

A total of 53 aqueous (SW) and collocated sediment (SE) surface water samples were collected for this investigation by DMG and CDPHE, respectively. All aqueous samples were analyzed for total and dissolved metals. All sediment samples were analyzed for total metals. Six pairs (SW and SE) of surface water samples were analyzed for organics and cyanide; six surface water samples were also analyzed for Total Organic Carbon. Five drinking water (3 groundwater and 2 surface water) samples were collected and analyzed for total and dissolved metals. Stream flow measurements allowed for metals loading calculations for all surface water and aqueous source locations.

High concentrations of metals were detected in the headwaters of Cement Creek, increasing noticeably following the introduction of mine drainage from the Queen Anne and Ross basin draining mines. Metals concentrations decrease as Cement Creek progresses downstream, especially notable following treatment of the American Tunnel and a portion of Cement Creek by Sunnyside Gold Corporation. Loading tends to increase as Cement Creek flows downstream, however, with obvious pulses of increased loading below the Queen Anne Mine, Mogul and South Mogul Mines, Red & Bonita Mine, and at locations below the American Tunnel, below the confluence with South Fork, below the confluence with Dry Gulch, below the confluence with Prospect Gulch and below the confluence with Georgia Gulch.

Concentrations of total aluminum, copper, iron, lead, manganese and zinc in **Cement Creek** were

"elevated", i.e., three times greater than background (CC-SW-1) for every downstream sampling location. Total concentrations of aluminum, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, nickel and zinc below the Gold King Mine were elevated above background (CC-SW-10) in the **North Fork** of Cement Creek. Total metal concentrations of both downstream locations in the **South Fork** of Cement Creek, i.e., below the Silver Ledge and Big Colorado Mines, were elevated above background (CC-SW-21) for aluminum, cadmium, cobalt, copper, iron, lead, manganese, and zinc. Total metal concentrations of all downstream locations in **Prospect Gulch** were elevated above background (PG-SW-1) for aluminum, cobalt, copper, iron, lead, manganese, and zinc, increasing in pulses following: introduction of the Galena Queen Mine in the headwaters; the confluence with tributaries contributing acid rock drainage; and, after the introduction of the Henrietta mine.

Metals Loading analyses reveal that the mines in the upper basin, i.e., the Queen Anne, Henrietta and Mogul Mines, contribute significantly to the metal loadings in upper Cement Creek. Mines in the Lower Basin, however, contribute only a small portion to the increasing metals loadings in Cement Creek as it flows toward the Animas River, except for a pulse of increased loading below Georgia Gulch, where the Kansas City Mines are located.

Cadmium, copper and zinc loadings increase in the upper basin, remain constant throughout the middle and lower basin, while slightly decreasing between the treatment of the American Tunnel/Cement Creek (CC-SW-33) and the confluence with Prospect Gulch (CC-SW-26), and increasing below Georgia Gulch and the Kansas city mines. Loading of aluminum, iron, lead and manganese increases as Cement Creek progresses downstream, with notable increases downstream of the American Tunnel/Cement Creek treatment location (CC-SW-33), as well as below the confluence with Prospect Gulch (CC-SW-26), and below Georgia Gulch (CC-SW-29).

Draining mine sources in the upper Cement Creek basin contribute significantly to the metal loadings, as the draining mines constitute as much as 50% of the flows measured in the receiving streams. As the flows increase downstream, however, metal loading contribution from the draining mine sources appears to be insignificant, although metals loading continues to increase.

The discharge from the American Tunnel as well as flow from Cement Creek at the American Tunnel is actively treated by Sunnyside Gold Corporation. The treated tunnel discharge and creek waters are returned to the Cement Creek channel immediately above sample location CC-SW/SE-24. The

American Tunnel drainage was not sampled. The treatment of the American Tunnel causes a drastic rise in pH at the sampling location immediately downstream. Total iron, lead and manganese loadings significantly increase at this location.

There is a positive correlation between stream acidity and metals loading in the surface water, negatively correlated to the sediment concentrations. This is especially noticeable in Cement Creek below Gladstone, following the treatment of the American Tunnel and a portion of Cement Creek, where draining mine contribution to the increased metal loading is insignificant. It may be interpreted that as stream acidity increases, metals in the sediment are mobilizing into the surface water column, increasing the metal loading in the surface water, consequently decreasing metals concentrations in the sediments. Naturally mineralized areas as well as non-point sources of pollution, i.e., potential mineral contribution from water contacting mine waste piles, may also contribute to metal loading.

Metals loadings increase as Prospect Gulch progresses downstream, with significant increases calculated below the Galena Queen Mine, below the mineralized tributaries, and again below the Henrietta Mine complex.

For aquatic life, the primary metals of concern are cadmium, lead, and zinc. These metals are widespread and are frequently present at concentrations which greatly exceed the Ambient Water Quality Criteria for surface waters found in the Superfund Chemical Data Matrix (SCDM) (Cadmium 1.1, Lead 3.2, and Zinc 110, values in micrograms per liter).

"Elevated" concentrations in sediment samples were observed for antimony and magnesium downstream of the background sample to a location below Corkscrew Gulch and the ferricrete deposit on the mainstem of Cement Creek (SE-8). Vanadium is elevated for most of the downstream sampling locations. Mercury was measured at above detection, and therefore elevated compared to background below the Red & Bonita Mine (SE-9). Antimony and zinc become elevated at the locations immediately below the confluence with Dry Gulch (SE-25) and below the confluence with Prospect Gulch (SE-26). Copper is elevated in Cement Creek below the confluence with Dry Gulch (SE-25). Elevated metals concentrations for sediment samples occurred at a lower frequency than that of aqueous samples,

All surface water and sediment samples analyzed for cyanide were found to be non-detect. Surface water samples analyzed for organics were found to be non-detect, except that Methylene chloride was found at low levels (2ug/L) in two surface water samples (CC-SW-24, Cement Creek below the confluence with South Fork and PG-SW-03, Prospect Gulch below the Galena Queen Mine) and three of the rinsate samples; one surface water sample contained a low concentration of acetone (CC-SW-24 @ 3ug/L). Three sediment samples were also found to contain low concentrations of methylene chloride (CC-SE-06, Cement Creek below the Mogul Mines @ 4ug/kg; CC-SE-12, the North Fork of Cement Creek below the Gold King Mine @ 4ug/kg; and CC-SE-24, Cement Creek below the confluence with South Fork @10ug/kg); one sediment sample was found to contain low concentrations of acetone (CC-SE-24 @ 7 ug/kg). Organic compound analytical results are presented in Table 3. Methylene chloride and acetone are common laboratory contaminants.

The risk posed to human health or the environment by the on-site and air pathways for the sources identified is considered to be minimal. There are no persons living on-site or within 200 feet of any of the identified sources. Although the sources located along Cement Creek, Prospect Gulch and their tributaries are uncovered and access is not restricted, these sources are located more than 1-mile from the nearest residents.

Three ground water wells and two surface water sources used for drinking water were sampled. Total lead concentrations in the Cement Creek Well (GW-1), and both total and dissolved lead concentrations in the Lenore Load adit (GW-4) and the Mineral Creek Well (GW-5) exceed the EPA recommended action level of 15 ug/l. The Lenore lode adit (GW-4) total and dissolved cadmium concentrations exceed EPA's recommended action level of 5ug/L. Except for the Lenore lode adit, the remaining drinking water samples had manganese concentrations ranging between 352 to 2130 ug/L; well above the current EPA Action Level of 200 ug/l. The groundwater well above Howardsville (GW-3) was the only site with manganese concentrations above the CDPHE health based advisory of 800 ug/l.

Letters have been sent to each of the drinking water users providing them with the analytical results. Retesting of each well/surface water was offered to each household, such that samples could be taken to determine the effectiveness of any in-home filtration system to remove cadmium, lead or manganese. In those instances where the lead and cadmium concentrations exceeded drinking water standards or action levels, the users were advised not to consume the water without adequate filtration.

## 6.0 REFERENCES

Colorado Department of Health, Hazardous Materials and Waste Management Division, 1988. *Standard Operating Procedures for Sampling of Hazardous Waste Sites*.

Colorado Department of Health, Hazardous Materials and Waste Management Division, 1994a. *Preliminary Assessment for the Kendrick & Gelder Smelting Company*. March.

CDH - Colorado Department of Health, Water Quality Control Division, 1994b. *Exhibit 3 - Upper Animas Water Quality Classification and Standards Proposal*. July.

CDPHE - Colorado Department of Public Health and Environment, Water Quality Control Division, 1994. *Memorandum Regarding Draft Report, Animas River Loading Analysis*. December 30.

Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division, 1995a. *Site Inspection Combined Sampling and Analysis Plan, West Willow Creek and East Willow Creek Sites, Creede Mining District Mineral County, Colorado*. May.

CDPHE, Hazardous Materials and Waste Management Division, 1995b. *DRAFT Animas Discovery Report Upper Animas River Basin*. October.

Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division. *Sample and Analysis Plan: Cement Creek Watershed*. July, 1996.

Colorado Division of Water Resources, 1996. *Groundwater Well Permit Data Base*,

February 29.

DMG - Colorado Division of Minerals and Geology, 1995a. *Reconnaissance Feasibility Investigation Report. Upper Animas River Basin.* March.

DMG, 1995b. *Animas River Targeting Continuation Project.* Fiscal Year 1996.

DMG, Inactive Mine Program, 1996. Telephone conversations and personal meetings with Jim Herron. July, August, September.

DMG, 1997. *Animas River Targeting Continuation Project, Upper Animas Watershed Sampling and Analysis Plan.* Fiscal Year 1997.

District Court, City and County of Denver, State of Colorado, 1996. *DRAFT Consent Decree and Order. Case No. 94 CV 5459. Sunnyside Gold Corporation, Plaintiff v. Colorado Water Quality Control Division of the Colorado Department of Public Health and Environment, Defendant.*

Harte, Holdron, Schneider, and Shirley, 1991. *Toxics A to Z A Guide to Everyday Pollution Hazards.* University of California Press, Los Angeles, California.

U.S. Environmental Protection Agency, 1990. *The Samplers Guide to the Contract Lab Program.*

USFWS - U. S. Fish and Wildlife Service, 1995. *Letter to the Colorado Department of Natural Resources, Division of Minerals and Geology in partial fulfillment of NEPA.* Received April.

U.S. Geological Survey, 1995. *Naturally Occurring and Mining Affected Dissolved Metals in Two Subbasins of the Upper Animas River Basin, Southwestern Colorado.*

Fact Sheet S-243-95. December.